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NAME OF CONTRACTOR: Paul M. Raccah
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PRINCIPAL INVESTIGATOR: PAUL M. RACCAH
PHONE NUMBER: (312) 996-3403

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Growth on A Virus versus Growth on B Surfaces

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SIXTH QUARTER

The sixth quarter has been devoted to the study of 7 samples provided by Night Vision Laboratories (See Tables Attached). We have addressed the question of growth on A versus growth on B surfaces and found that the differences are clear. We intend to study this question more actively in the coming quarter. We have addressed as well the question of comparison between layers grown by LPE versus layers grown by VPE. Here again we have seen what we have reported before, namely, that VPE layers are graded in composition and we have now established that this grading is accompanied by extensive strains. In comparison layers grown by LPE are superior.

Accepted	
NTIS Class	
DTIC TAB	
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Justification	
By <u>perform 50</u>	
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Availability Codes	
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EER AND ASE DATA FROM THE UNIVERSITY OF ILLINOIS
FOR BOTH LIQUID AND VAPOR PHASE EPITAXIAL MCT FILMS
GROWN AT NIGHT VISION.

GROWTH FACES- A(111) WITH ONE VPE B(111) SAMPLE
GROWTH SUBSTRATE-CDTE

PHYSICAL MEANING OF ΔE_1 and $\Delta \alpha^2$

$$\Delta E_1 = \Delta E_{cb} - \Delta E_{vb}$$

$$\Delta E_1 > 0 \text{ means } \Delta E_{cb} > \Delta E_{vb}$$

$$\Delta E_1 = 0 \text{ means } \Delta E_{cb} = \Delta E_{vb}$$

$$\Delta E_1 < 0 \text{ means } \Delta E_{cb} < \Delta E_{vb}$$

TWO CAUSES FOR THE CONTRIBUTION

a - Piezoelectric effect in non-centrosymmetric materials.

b - Breakdown of symmetry induced by overlapping structural defects.

$\Delta \alpha^2$ is proportional to the density of polarizable defects is in first

approximation related linearly to ΔE_1

E_1 -transition energy, yields composition fraction (x value)
 Γ -line width, related to crystal quality
 θ -phase, related to type

LPE #051084(A)

DEPTH IN MICRONS	E ₁ EER	ASE	X EER	Γ EER	θ EER	Δ ₁	Δσ ₂
0.0	2.341	2.449	0.267	0.098	4.198	-19.270	-10.115
1.375	2.404	2.397	0.331	0.114	4.394	-16.765	- 4.788
2.750	2.399	2.393	0.327	0.110	4.489	-13.142	- 4.392
4.125	2.390	2.395	0.318	0.101	4.321	-24.993	- 5.755
5.500	2.397	2.399	0.324	0.111	4.491	- 9.604	- 3.582
6.875	2.406	2.399	0.333	0.108	4.439	-12.232	- 2.506
8.250	2.437		0.363	0.129	4.894	2.392	- 4.039
9.625	2.544	2.519	0.458	0.189	5.977	4.005	- 0.771

LPE #050784(A)

DEPTH IN MICRONS	E ₁ EER	ASE	X EER	Γ EER	θ EER	Δ ₁	Δ ₀₂
0.0	2.260	2.268	0.176	0.088	4.138	-25.166	- 9.760
1.35	2.378	2.366	0.306	0.109	4.546	- 8.889	- 3.223
2.70	2.370	2.366	0.297	0.110	4.484	-10.236	- 3.460
4.04	2.369	2.360	0.296	0.108	4.565	- 9.470	- 3.795
5.38	2.365	2.361	0.292	0.105	4.580	- 7.646	- 3.353
6.73	2.362	2.356	0.289	0.103	4.563	- 7.756	- 3.246
8.08	2.361	2.352	0.288	0.113	4.871	0.042	- 3.529
9.42	2.357	2.355	0.284	0.102	4.469	- 7.076	- 3.314
10.77	2.354	2.355	0.281	0.097	4.382	-11.906	- 3.490
12.12	2.359	2.361	0.286	0.099	4.377	-12.177	- 3.591
13.46	2.379	2.384	0.307	0.101	4.430	-15.780	- 3.784
14.81	2.419	2.461	0.345	0.113	4.550	-21.923	- 4.872
16.15	2.508		0.427	0.181	4.855	- 8.956	- 4.574
17.50			0.995				

LPE #031484(A)

DEPTH IN MICRONS	E- EER	ASE	X EER	Γ EER	θ EER	Δ ₁	Δ ₂
0.0	2.212	2.230	0.115	0.098	4.136	- 8.196	- 4.490
1.35	2.358	2.352	0.285	0.114	4.569	- 8.443	- 3.272
2.70	2.353	2.351	0.279	0.106	4.383	- 7.251	- 2.656
4.05	2.351	2.349	0.278	0.111	4.531	- 5.938	- 2.285
5.40	2.355	2.355	0.282	0.107	4.439	- 7.653	- 2.543
6.75	2.360	2.353	0.287	0.108	4.451	- 7.704	- 2.776
8.10	2.366		0.293	0.106	4.387	- 8.231	- 2.686
9.45	2.397	2.383	0.325	0.108	4.368	-10.928	- 3.063
10.80	2.458	2.439	0.382	0.123	4.421	-13.524	- 2.778
12.15	2.570	2.544	0.480	0.215	4.611	-12.095	- 2.333
13.5			0.993				

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L P 8 431484 (F)

NV314A

VPE #042684(A)

DEPTH IN MICRONS	E ₁ EER	ASE	X EER	Γ EER	θ EER	Δ ₁	Δ ₂
0.0	2.330	2.324	0.256	0.115	4.382	- 8.351	- 6.624
0.53	2.336	2.332	0.262	0.084	3.771	-79.986	-16.852
1.05	2.338		0.264	0.103	4.238	-10.444	- 3.584
1.57	2.343	2.340	0.269	0.103	4.217	- 9.519	- 3.202
2.10	2.343	2.347	0.269	0.102	4.223	-10.482	- 3.276
2.63	2.349	2.347	0.276	0.105	4/183	-12.394	- 3.897
3.15	2.355	2.358	0.282	0.106	4.268	- 9.586	- 3.153
3.68	2.360	2.359	0.287	0.103	4.214	-10.539	- 3.205
4.21	2.364	2.360	0.291	0.099	4.146	-24.579	- 5.481
4.73	2.364	2.365	0.291	0.106	4.357	- 9.637	- 2.226
5.26	2.387	2.369	0.315	0.106	4.497	- 4.-15	- 2.705
5.78	2.372	2.372	0.299	0.110	4.300	- 9.545	- 2.421
6.31	2.375	2.375	0.302	0.101	4.174	-16.254	- 3.649
6.84	2.382	2.381	0.310	0.108	4.216	-12.545	- 3.291
7.36	2.389	2.390	0.316	0.110	4.277	-11.563	- 2,409
7.89	2.404	2.404	0.331	0.105	4.240	-13.190	- 3.209
8.74	2.432	2.433	0.358	0.111	4.282	-13.287	- 2.959
9.58	2.445	2.440	0.370	0.110	4.308	-13.760	- 3.037
10.42	2.459	2.450	0.383	0.110	4.278	-16.170	- 3.333
11.26	2.469	2.461	0.393	0.113	4.247	-17.882	- 3.447
12.10	2.490	2.477	0.411	0.121	4.604	- 6.673	- 2.670
12.94	2.547	2.547	0.460	0.139	4.893	- 6.253	- 2.815
14.21	2.585		0.492	0.152	4.893	- 7.107	- 3.303
15.47	2.637	2.610	0.533	0.188	5.095	- 7.241	- 3.773
16.73		2.729					

VPE #042584(A)

DEPTH IN MICRONS	E ₁ EER	ASE	X EER	Γ EER	θ EER	Δ ₁	Δσ ²
0.0	2.398	2.359	0.325	0.102	5.917	34.951	- 0.216
0.48	2.384	2.373	0.312	0.106	4.138	-15.045	- 3.586
0.95	2.399	2.377	0.326	0.113	4.492	- 6.171	- 3.056
1.43	2.405		0.332	0.104	4.245	-13.469	3.811
1.90	2.419	2.402	0.346	0.112	4.559	- 4.358	- 3.291
2.38	2.419	2.406	0.346	0.104	4.114	-20.869	- 5.194
2.85	2.424	2.410	0.351	0.104	4.213	-20.358	- 5.004
3.33	2.435	2.424	0.351	0.109	4.313	-13.119	- 3.632
3.81	2.440	2.430	0.365	0.106	4.160	-19.369	- 4.461
4.29	2.445	2.435	0.371	0.108	4.157	-21.594	- 4.590
4.76	2.478	2.444	0.400	0.124	4.632	- 2.587	- 3.193
5.24	2.459	2.447	0.383	0.107	4.073	-22.306	- 4.361
5.71	2.491	2.466	0.394	0.128	4.302	-33.463	- 5.395
6.19	2.487	2.474	0.409	0.160	4.757	- 6.959	- 1.207
6.67	2.502	2.498	0.422	0.122	4.214	-15.984	- 2.722
7.14	2.529	2.526	0.445	0.133	4.413	-18.058	- 2.571
7.90	2.539	2.534	0.454	0.107	4.033	-41.850	- 5.147
8.67	2.553	3.554	0.466	0.113	4.035	-33.686	- 3.889
9.43	2.572	2.577	0.482	0.123	4.127	-28.224	- 3.074
10.19	2.670	2.601	0.559	0.163	0.105	10.879	- 0.548
10.95	2.652	2.605	0.545	0.201	0.310	4.405	- 0.073
11.71	2.637	2.700	0.533	0.249	5.160	- 4.639	- 1.051
12.86	2.691	2.793	0.575	0.297	4.974	- 4.354	- 0.916
15.14	3.375		1.00	0.130	0.843	5.292	0.694

VPE #042584(B)

DEPTH IN MICRONS	E ₁ EER	X ASE	Γ EER	θ EER	Δ ₁	Δσ ²
0.0	2.347	2.331	0.274	0.097	5.293	4.892
0.48	2.351	2.330	0.278	0.125	5.177	2.557
0.95	2.352	2.343	0.279	0.101	5.215	3.309
1.43	2.362		0.289	0.102	5.174	3.211
1.90	2.360	2.347	0.287	0.102	5.186	3.392
2.38	2.367	2.354	0.294	0.102	5.136	3.337
2.85	2.376		0.303	0.101	5.145	3.568
3.33	2.378	2.362	0.306	0.102	5.175	3.141
3.81	2.378	2.369	0.305	0.096	5.212	3.187
4.29	2.394	2.377	0.321	0.105	5.176	3.195
4.76	2.406	2.378	0.333	0.083	5.517	6.705
5.24	2.401	2.378	0.328	0.102	5.180	3.490
5.71	2.407	2.393	0.334	0.109	5.151	3.003
6.19	2.418	2.401	0.345	0.106	5.125	3.206
6.67	2.426	2.416	0.352	0.125	5.103	2.732
7.14	2.423	2.420	0.350	0.112	5.027	3.101
7.90	2.440	2.428	0.365	0.109	5.095	3.779
8.67	2.450	2.437	0.377	0.116	5.041	3.260
9.43	2.467	2.456	0.390	0.145	5.026	1.730
10.19	2.479	2.469	0.402	0.131	4.989	2.624
10.95	2.504	2.496	0.423	0.125	5.100	3.138
11.17	2.590	2.581	0.496	0.160	5.311	1.662
12.86	2.745	2.710	0.614	0.152	5.432	2.949

NIGHT VISION COMPARATIVE ANALYSIS OF NIGHT VISION (IR TRANSMISSION AND REFLECTANCE) AND UNIVERSITY OF ILLINOIS DATA (EER, ASE). ALL DATA WAS PLOTTED FOR VISUAL COMPARISON.

LPE ON A(111) CDTE

EER AND ASE E₁ TRANSITION ENERGIES AGREE WELL AND YIELD COMPOSITION FRACTIONS (X-VALUES) WHICH COMPARE TO IR TRANSMISSION DATA.

COMMENTS:

1. THE SURFACES OF ALL THREE SAMPLES ARE MERCURY RICH, AND COMPOSITION DEPTH PROFILES ARE NEARLY FLAT WITH A 4 MICRON INTERDIFFUSION WIDTH AT THE SUBSTRATE.
2. THE 20 MIN. LONGER GROWTH OF #050784(A) RELATIVE TO #051084(A) RESULTED IN A 6 MICRON THICKER LAYER WITH AN X VALUE REDUCED BY .02.

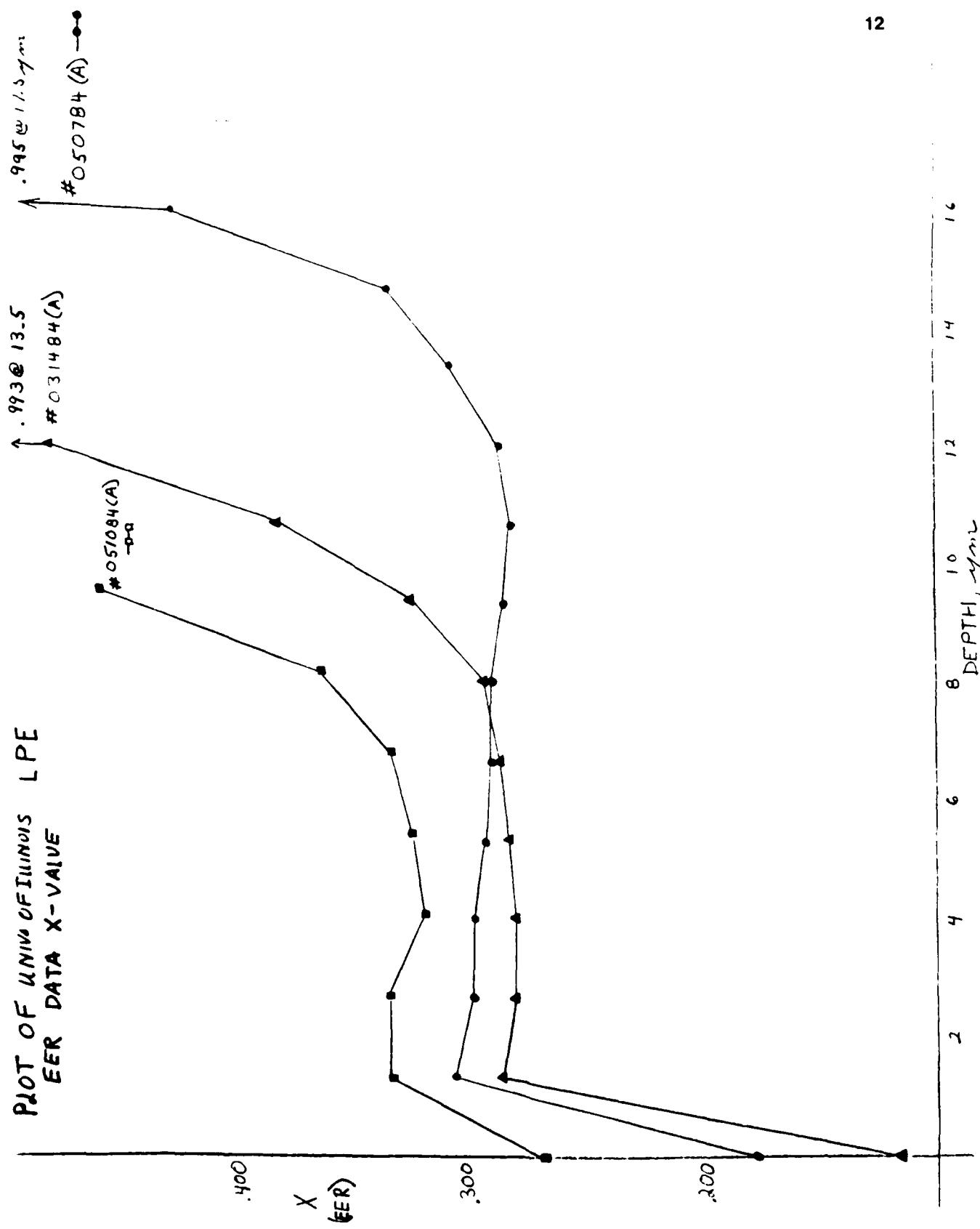
VPE ON A(111) AND B(111) CDTE

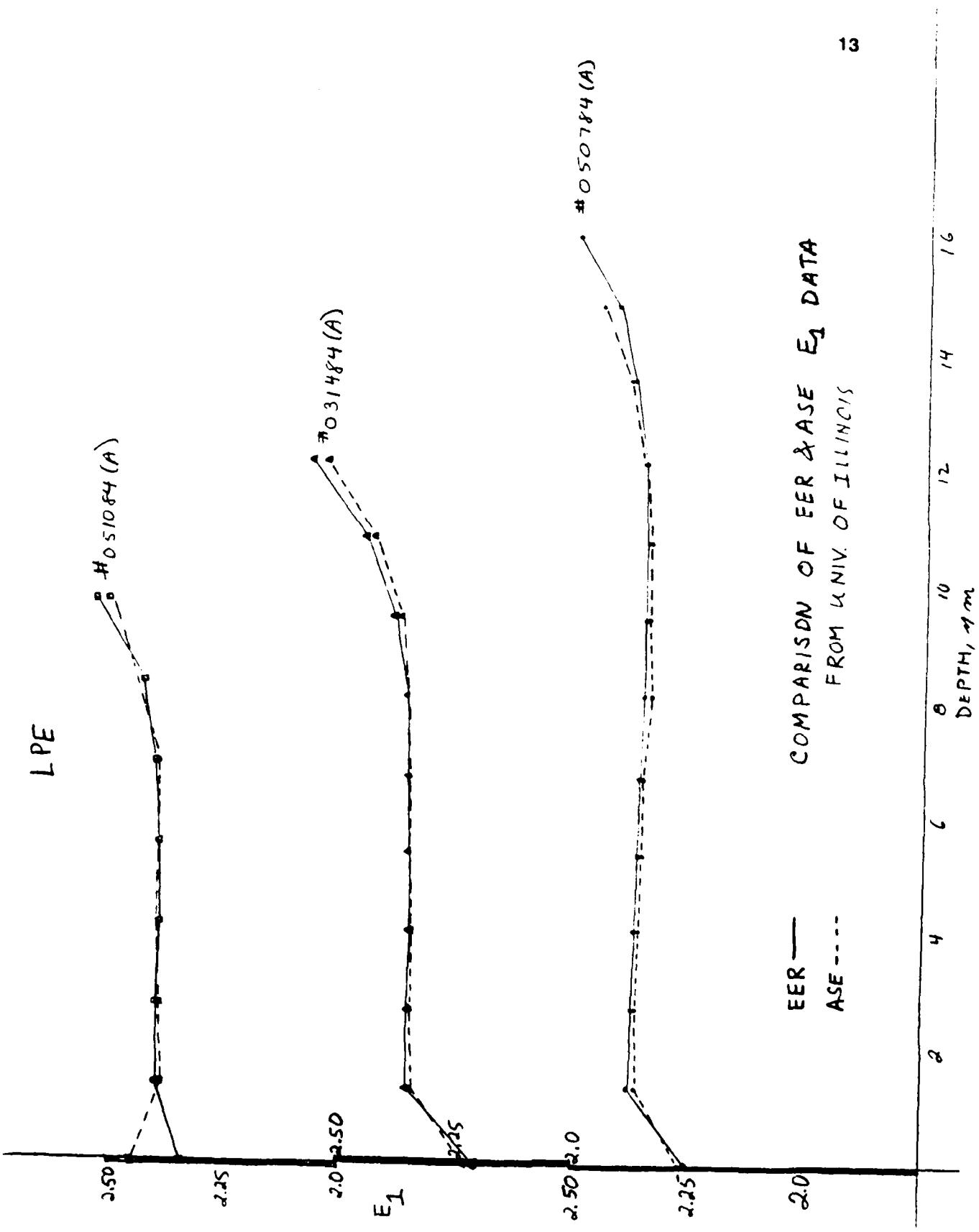
EER, ASE, AND REFLECTANCE E₁ TRANSITION DATA AGREE WELL EXCEPT FOR A CALIBRATION SHIFT OF THE REFLECTANCE DATA.

COMMENTS:

1. THE LAYERS ARE GRADED IN COMPOSITION (X-VALUE) YIELDING A SOFTER EDGE, RELATIVE TO THE LPE MATERIAL, IN THE IR TRANSMISSION DATA.
2. EER, ASE, AND IR TRANSMISSION CLEARLY SHOW THE EFFECTS OF GROWTH FACE FOR SAMPLES #042584(A) AND #042584(B).

PILOT OF UNIVERSITY OF ILLINOIS
EER DATA X-VALUE





LPE

LINE WIDTH DATA PLOT
OF UNIV. OF ILLINOIS EER DATA

.210

TP
(EER).190
.170
.150

.130

.110

.09

.6
4
2
0
2
4
6
8
DEPTH, mm

16

14

12

10

8

6

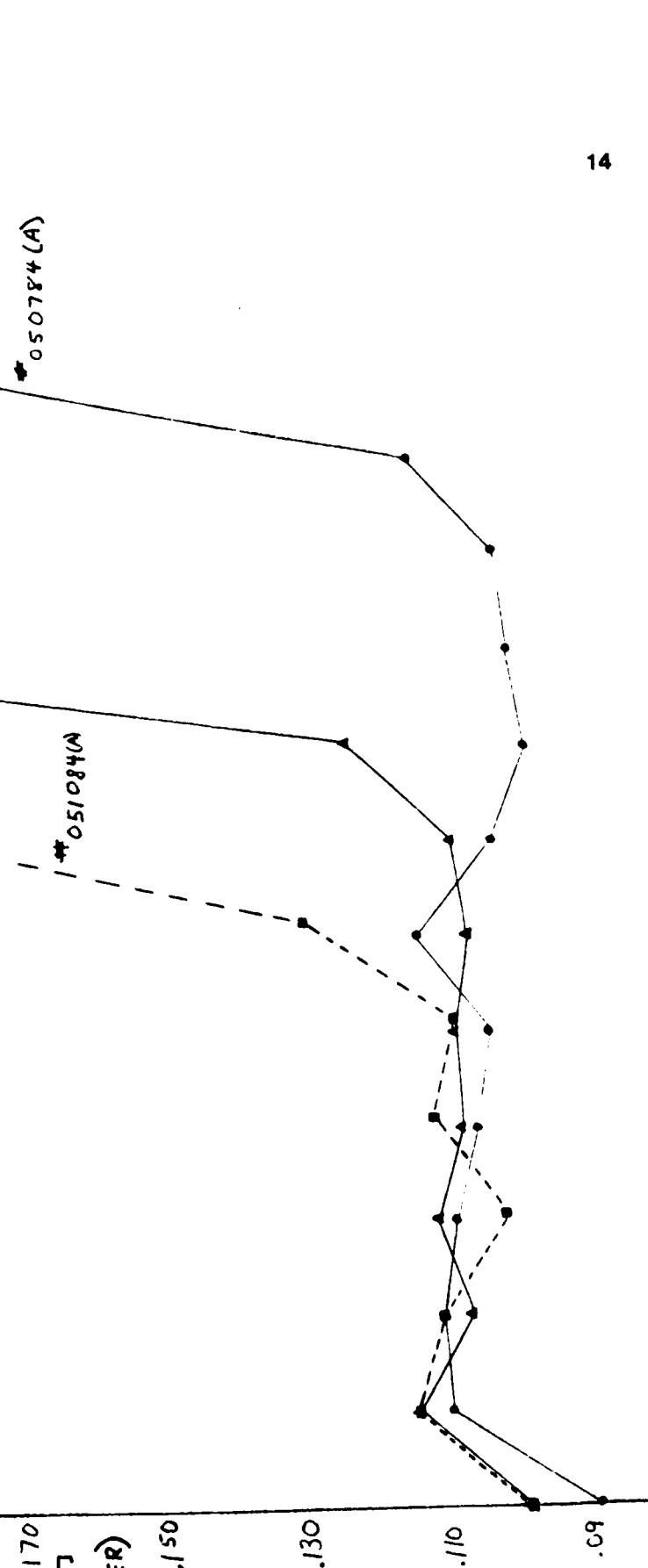
4

2

0

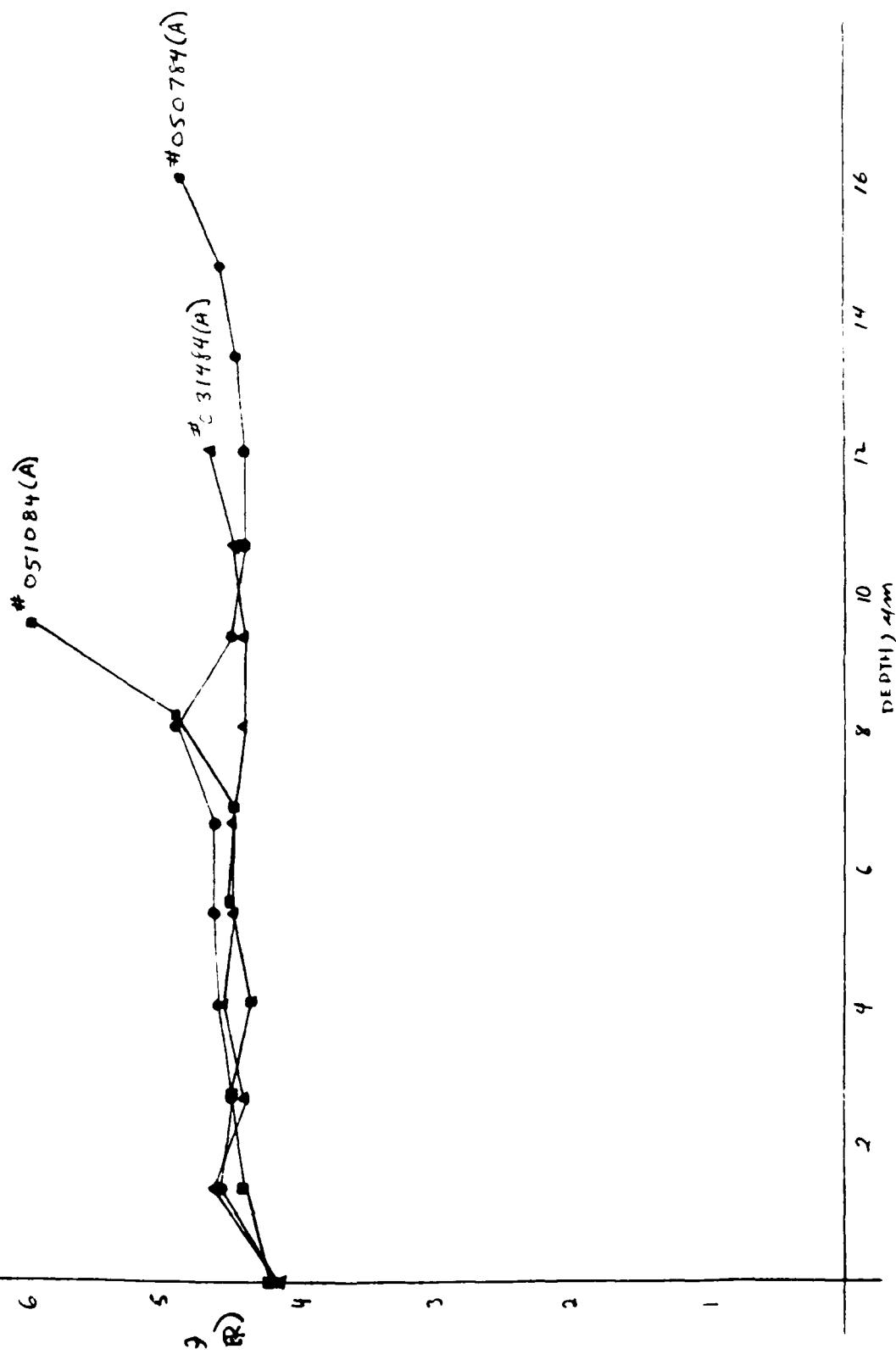
031484 (A)

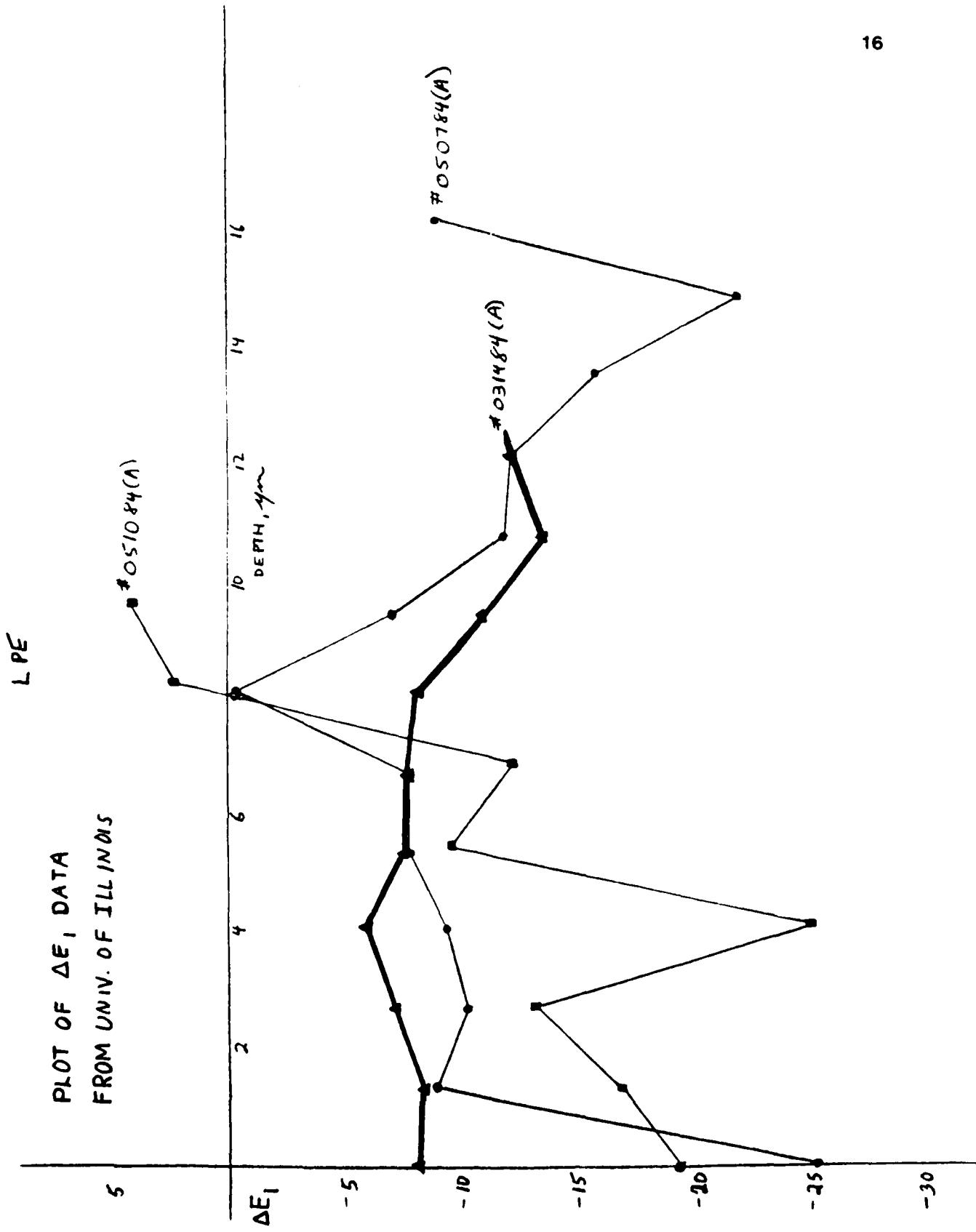
051084(A)

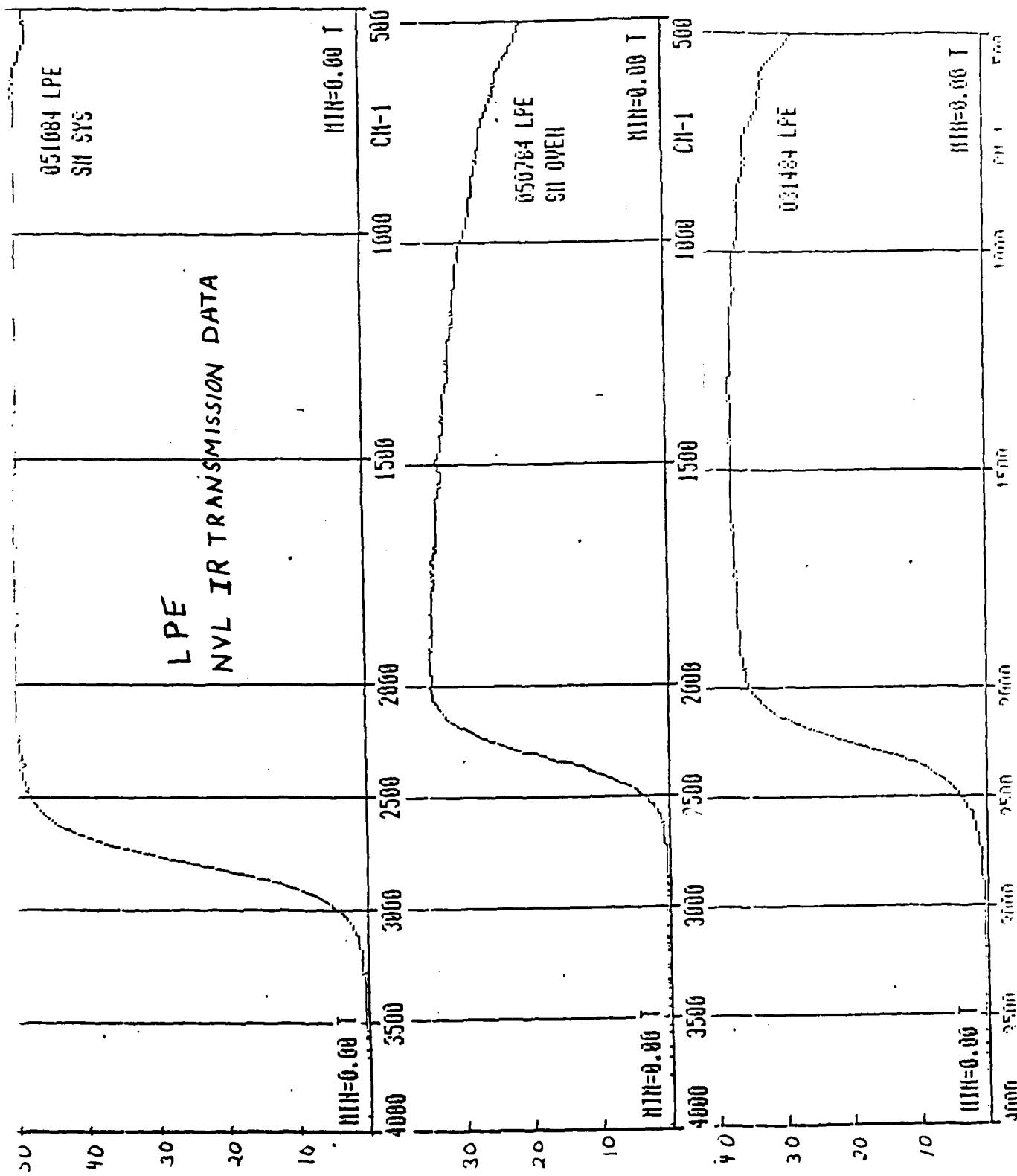


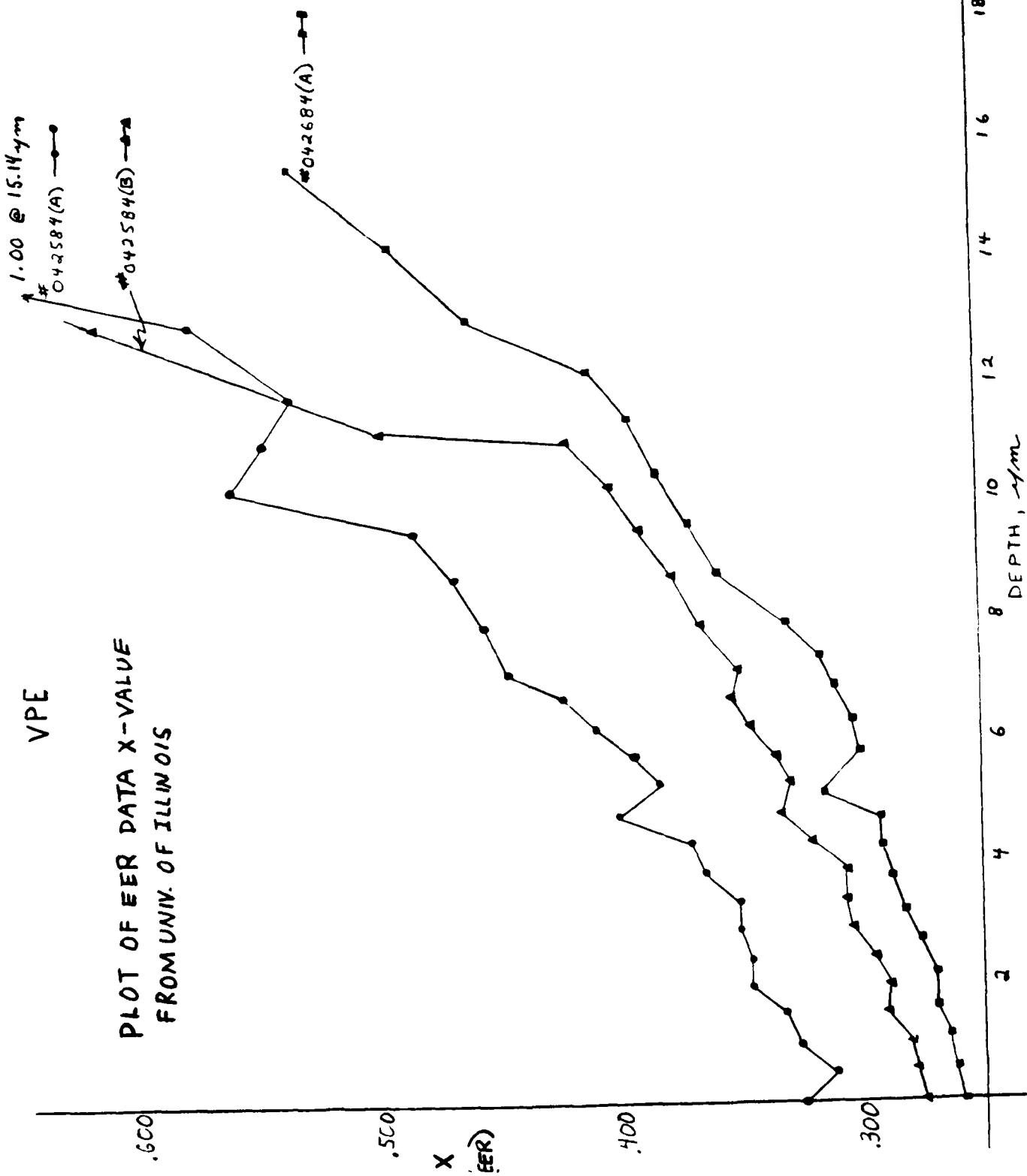
LPE

PLT OF θ DATA
FROM UNIV. OF ILLINOIS









042584(B)

VPE

E₁

2.50

2.25

2.00

1.50

2.25

2.00

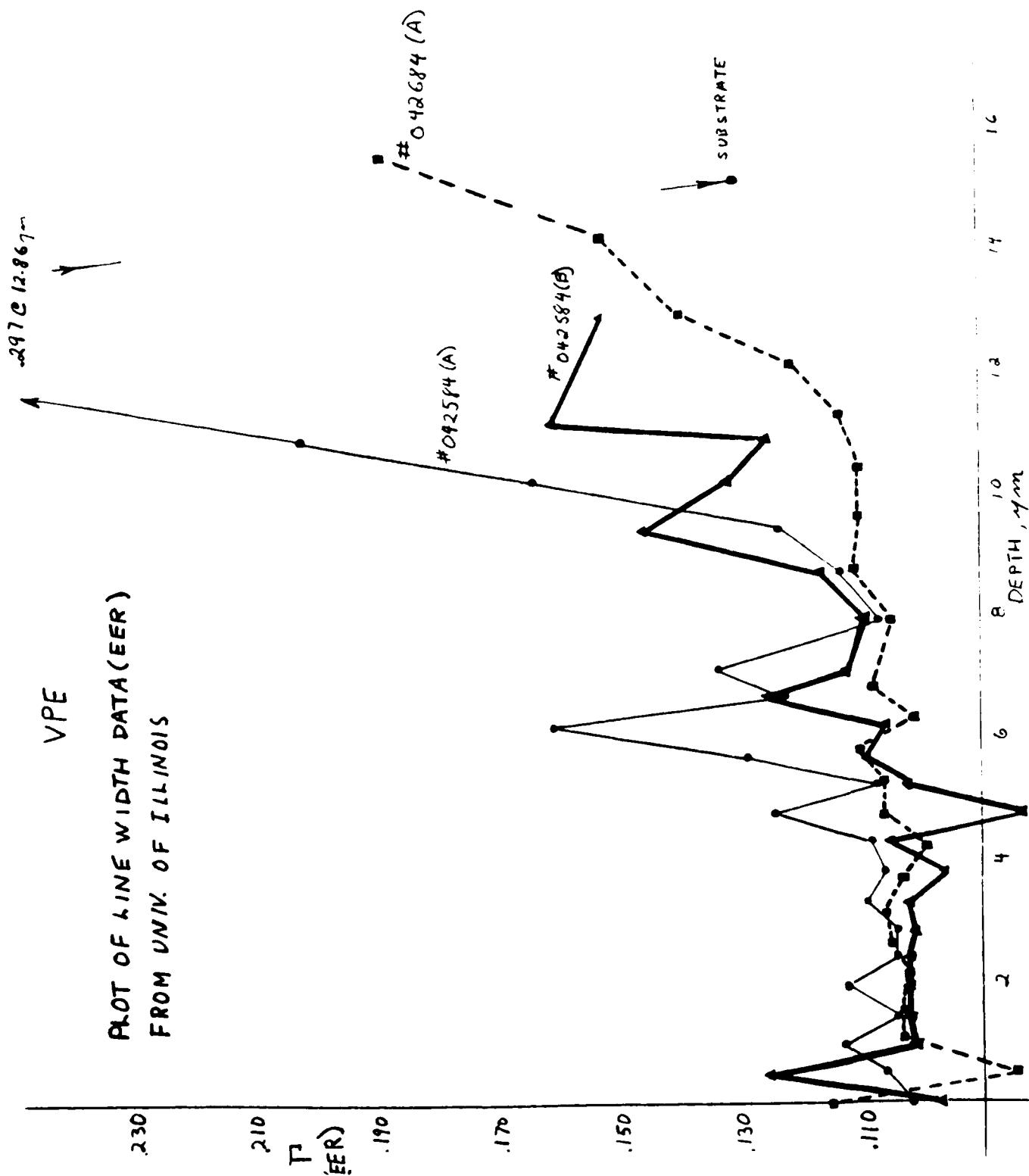
042684(A)

042584(A)

COMPARISON OF EER & ASE E₁ DATA (A. ILLUM.)
AND REFLECTANCE DATA (NIGHT VISION)

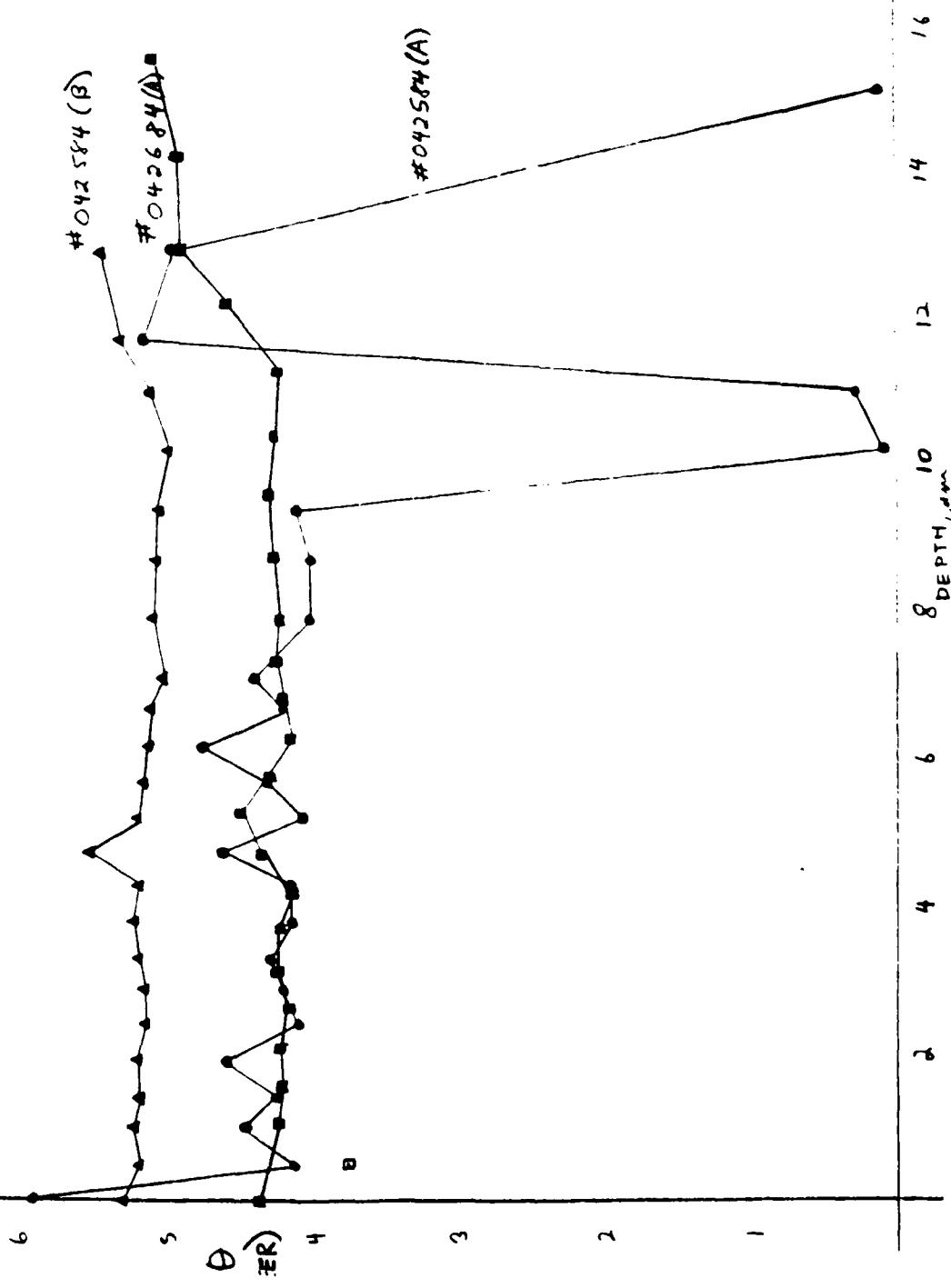
EER —
ASE ---
Reflectance —*— [NORMALIZED $\rightarrow \left(\frac{E_1}{E_0}\right)^{12.24m} = \text{Depth}]$

2 4 6 8 10 12 14 16
DEPTH, m



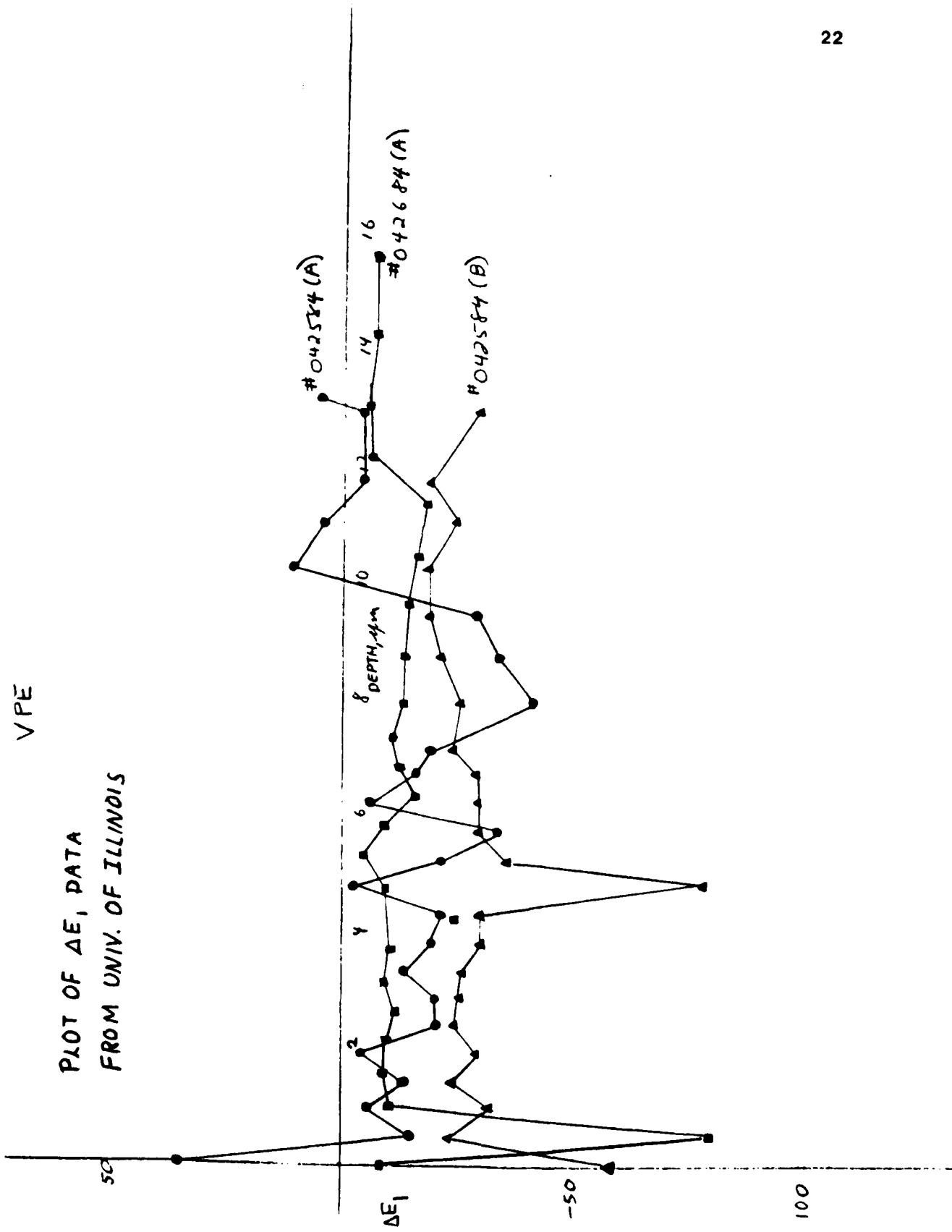
VPE

PILOT OF θ DATA
FROM UNIV. OF ILLINOIS



VPE

PLOT OF ΔE , DATA
FROM UNIV. OF ILLINOIS



NVL DATA

Normalization of Reflection Data VPE #042584 (A)

$$\frac{x_t}{160_{\text{time}}} (12.2) = \text{depth}$$

E_1	x_{time}	Depth
2.307		0.00
2.299		.05
2.330		.09
2.309	20.92	1.60
2.314	32.00	2.44
2.319	41.85	3.19
2.330	51.69	3.94
2.342	60.31	4.60
2.348	70.15	5.35
2.372	80.00	6.10
2.401	90.31	7.04
2.433	103.38	7.88
2.443	112.49	8.58
2.473	123.08	9.38
2.519	134.15	10.23
2.546	144.00	10.98
2.614	153.85	11.73